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January 7, 1982  
Project No. 81879/102-55

Mr. Ben White  
Total Petroleum, Inc.  
East Superior Street  
Alma, MI 48801

Dear Mr. White:

Re: Hydrogeological Review of Useable Aquifer in Refinery Area

Pursuant to your interest in defining the useable aquifer or aquifers in the area of the Total Petroleum Refinery Company, we have completed a review of the ready available data for this area.

This data consisted of a letter report by Williams & Works, Engineers, and dated October 26, 1979, summarizing (1) the lateral and vertical extent of five subsurface disposal pits, and (2) determination of the direction of groundwater movement together with the hydraulic gradient of the uppermost water-bearing materials beneath the company soil farm.

The data also consisted of a report by the U.S. Geological Survey, dated 1963, entitled Groundwater Resources of the Alma Area, Michigan. This publication is further defined as "Geological Survey Water-Supply Paper 1619-E.

Location of Area

The Total Petroleum Company refinery is located in the City of Alma, Michigan which is situated in portions of Pine River Township and Arcada Township, Gratiot County. The Pine River flows northeastward through the center of the City of Alma. The subject soil farm for the refinery is located south of East Superior Street in the eastern portions of the city.

Local Geology

Nearly all groundwater supplies in the Alma area are obtained from the unconsolidated glacial deposits situated on top of the Saginaw formation. The Saginaw formation is the consolidated bedrock surface in the Alma area and consists of sandstone with streaks of limestone.

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The glacial drift, in the Alma area, has been reported to be as much as 550 feet thick. These deep areas are found where the drift fills any deep valleys within the bedrock surface. Most wells which tap the drift are less than 150 feet deep. The unconsolidated materials consist of till, lake deposits, and outwash.

Till is a heterogeneous mixture of rock debris which was deposited directly by the glacial ice. The materials range in size from clay to boulders. Lake deposits consist of well sorted clay, silt, and sand laid down in former glacial lakes. Outwash is composed of well sorted sand or gravel deposited by the streams which flowed from the melting glaciers.

The permeable sands and gravels comprising the outwash deposits are the most productive sources of fresh water in the Alma area. The City of Alma has developed potable wells in the western portions of the city within a narrow strip of buried outwash. Whereas the thickest portions of the permeable outwash materials occur along and parallel to the Pine River, there are reports of a narrow channel of buried outwash in the eastern part of the city. Several industrial wells tap this aquifer in this area. The wells of the Total Petroleum Company are believed to be finished within these materials.

Our review of the available data included a well log of one of the company's production wells which is located in the area of the soil farm. This log is given below.

Total Petroleum Company  
Production Well - South Field  
14-inch Diameter Casing - Drilled October, 1952

<u>Formation</u>	<u>From</u>	<u>To</u>
Top Soil	0	1
Clay	1	11
Sand & Gravel	11	16
Clay, hard, stoney	16	58
Brown Sand	58	63
Sand & Gravel, gravel large and dry	63	86
Brown Sand	86	90
Sand & Gravel, large rocks, dry	90	99
Sand & Gravel, rocks with some clay	99	102
Clay	102	105
Sand & Gravel, large gravel, water	105	119
Clay	119	120
Hole terminated in clay		
Static water level - 55 feet		

Our recent telephone conversations have indicated that two other production wells in the area of the soil farm are completed in the area of 105 to 130 feet deep.

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The drillers log shown above indicates (1) that the local aquifer exists in the interval of 105 feet to 119 feet, (2) that the aquifer exists under artesian conditions, and (3) that the aquifer is protected by a total thickness of 55 feet of relatively impervious clay and hardpan.

As part of a hydrogeological study conducted in 1979, numerous shallow borings were made and several monitoring wells installed. The borings extended to a depth of 2 feet to 23 feet while the monitoring wells were completed in the interval of 17 feet to 23 feet. A review of the drillers logs of this work indicated that the shallow materials consisted of a mixture of sand, gravel and clay. Several of the borings and all of the monitoring wells encountered saturated conditions within the drift. The water-bearing materials tapped by the monitoring wells consist predominately of fine, sandy, silty deposits. A report of this previous work indicated that these materials exhibit very low yields. The formation ranged from two to nine feet in thickness, and the maximum depth was 20+ feet below the ground surface. A statement from the earlier report mentioned that "due to its shallow depth and low yield capacities, this formation is unsuitable for use as a potable, industrial or agricultural water supply aquifer." We concur with this statement.

#### Groundwater Use and Effects of Pumping

The U.S.G.S. Water Supply Paper 1619-E, mentioned previously, indicated that the City of Alma municipal water supply is obtained from wells within the buried outwash and located west of the city. This paper also mentioned that several industrial wells were finished within the buried outwash, in the eastern portions of the city. These industrial wells undoubtedly include those of the Total Petroleum Company. This government report stated that the gradual increase in pumpage from the buried outwash had resulted in a gradual lowering of water levels and a steady increase in the size of the composite cone of depression. The limits of the cone of depression extended beyond the city limits of Alma.

Several aquifer performance tests were conducted during the U.S.G.S. study. These tests provided the solution of the hydraulic characteristics of the buried outwash aquifer. With these constants we can predict the cone of depression about a well or group of wells after extended pumping periods. As mentioned previously, the buried outwash aquifer occurs under artesian conditions. The release of water to a well under artesian conditions results in a change (lowering) of the pressure gradient within the aquifer. The cone of depression therefore expands very rapidly and for considerable distances under these conditions as compared to water table conditions.

Of primary concern, in this instance, is not the extent of the cone of depression about a series of wells, but rather the potential for the downward migration of unfavorable quality water into the deeper aquifer. Even though we can say that the company's soil farm is within the cone of influence of the company's production wells, this is not to say that any shallow degraded groundwater will be induced into the lower aquifer.

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As mentioned earlier, a review of one production well log indicates a total of 55 feet of impermeable cover over the aquifer. Our verbal discussions indicated that the company's other two production wells are completed within the same formation. We would, therefore, expect similar protective thicknesses over the aquifer in these areas. The U.S.G.S. report indicates that the buried outwash aquifer underlies most of the western part of Alma. Furthermore, this formation is overlain by 10 feet to 30 feet of clayey like sediments which form a leaky aquiclude (impermeable) from a shallow sand aquifer. From the drillers log of the production well presented earlier we can see that the shallow aquifer, mentioned in the U.S.G.S. report, is absent in the area of the soil farm.

This same well log also indicated 10 feet of clay in the interval of 1 to 11 feet. Our review of all other subsurface work suggests that this interval may contain some lenses of sand and gravel. The total thickness of impervious cover material, in the area of the soil farm therefore, may range from 45 to 55 feet.

#### Summary and Conclusions

Our review of all readily available data associated with the useable aquifer in the vicinity of the Total Petroleum Company soil farm has indicated the following:

1. The shallow materials consist of a mixture of sand, silt, clay and gravel which are saturated.
2. These materials are unsuitable for use as an aquifer due to their depth and limited permeability.
3. The usable aquifer consists of a deposit of buried outwash material. The depth of this aquifer is approximately 105 to 120 feet.
4. The usable aquifer exhibits artesian hydraulic conditions with approximately 45 to 55 feet of impermeable cover over the aquifer.
5. The Total Petroleum Company operates three production wells which are completed within this aquifer.
6. The cone of depression resulting from the pumping of the company's production wells extends beyond the limits of the company soil farm and adjoining refinery.
7. The type and thickness of the overlying aquiclude should prevent the vertical migration of any degraded shallow groundwater into the deeper useable aquifer.

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If you have any questions concerning these interpretations or findings, we will be pleased to discuss them with you.

Very truly yours,

FISHBECK, THOMPSON, CARR & HUBER, INC.

A handwritten signature in cursive script, reading "Walter W. Meinert".

Walter W. Meinert, P.E.

A handwritten signature in cursive script, reading "Forrest Winchester".

Forrest Winchester, P.E.

slw

cc: Mr. Pat Lincoln